

THE FLORIDA TREE SNAILS OF THE GENUS *LIGUUS*

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INTRODUCTION

The following pages are the result of studies and collections made in the field during a residence of nearly 30 years in southern Florida and of six visits to Cuba which permitted me to work over the island from Cape San Antonio at the west end to within a hundred miles of Cape Maisi at its eastern point. I have also visited Haiti and collected *Liguus virgineus* in considerable quantity. This work on the islands was not at all thorough as it was done in connection with that of getting plants and collecting the land snail fauna in general, but it gave me a considerable amount of *Liguus* material and ideas of its distribution. I have made a rather careful search in Florida, having tramped the East Coast Railroad several times from Key Largo where it enters the Upper Keys to Key West at its terminus and back again. I have visited practically every one of these islands which have ever had *Liguus* and made collections on them. On the mainland I have been in nearly every locality in which these snails were found, and many of these places I have visited and worked over a number of times. In all I have some kind of *Liguus* material from over 300 Floridian localities, most of which I have personally collected. For nearly 26 years I have had an opportunity to study these snails in my own hammock within a hundred feet of my door.

Long before I began to collect (1882) man had wrought great destruction to the hammocks in which they live so that certain forms were on the verge of extinction and in some localities all evidence of them was obliterated, and at present the *Liguus* are almost exterminated in Florida. Great areas of forest have been recently cut in Cuba in order that sugar cane might be grown, and it is probable that it will be a short time only when these snails will be wiped out entirely in many localities in that island. Very much of the evidence necessary to a complete study of them is therefore missing, and the future student will only be able to use material collected



long ago. So much of the evidence as to distribution and other matters is gone that anyone attempting to work out the story of these mollusks finds himself in the position of a person who tries to read an old, torn, and faded book with many of the pages missing.

In Cuba the earlier collectors seemed to think that the different forms of *Liguus* were merely color variations that meant absolutely nothing, so they took but little pains to get complete sets of the varieties or to record definite localities for them, and they mostly lumped all their material together and labeled it "*Achatina fasciata*, Cuba." If only complete collections of *Liguus* could have been made in the island and in Florida before the destruction of the forests began and the records of localities carefully kept I am satisfied that we could not only have deciphered their past history but by their aid we could have worked out in considerable detail the geology of both regions.

It has been objected that I have given too many names to color varieties of the Floridian *Liguus*. While I do not attach any great importance to most of these, yet I am sure that they stand for different phases of development and distribution. It seems to me that it is better to have some kind of a name for a variety, such as *mosieri* or *castaneus*, than to have to say "the small form of *crenatus* with narrow spiral green lines" or "the dark chestnut variety of *fasciatus* having a few yellowish markings on the spire." A considerable number of the *Liguus*, which Dr. H. A. Pilsbry and I have named, are, doubtless, fertile hybrids; but they, as well as the rest, help to tell the story of the past development, migration, and distribution of these snails.

I am greatly indebted to Mr. Charles Mosier, former custodian of the Royal Palm State Park, the great forest of which swarms with *Liguus*. Mr. Mosier made careful studies of these snails for years in this and many other hammocks in Florida and has freely given me the result of his observations.

The late Mr. John B. Henderson generously made it possible for me to visit the island of Haiti and to make a half dozen trips to various parts of Cuba, also to collect in places on the Florida Keys which were difficult of access. I am also under obligations to Dr. Carlos de la Torre, of Habana, who allowed me to examine his great collection and make notes on it, also for many valuable specimens of Cuban *Liguus*.

This paper is respectfully dedicated to Charles Mosier, friend, master woodman, naturalist, and companion on many collecting trips, and to whose knowledge and assistance I am greatly indebted for much of what appears in these pages.

THE GENUS *LIGUUS* IN FLORIDA

The genus *Liguus* includes about a dozen species of large land snails inhabiting the northern and northwestern parts of South America, the island of Cuba, Haiti, Cozumel, off the eastern coast of Yucatan, and the more tropical part of Florida. The six species which inhabit the islands and Florida are brightly colored and strictly arboreal in habits, and they doubtless constitute a well-defined subgenus.

Cuba is an old island, geologically speaking, and has doubtless been inhabited by *Liguus* for a long time, possibly back into the Miocene. It is quite likely that the genus extended into Haiti at a time when the land was much more elevated than it is to-day and that island and Cuba were united.

Although Florida is separated from Cuba by a deep channel 90 miles wide it seems certain that it has derived all its *Liguus* stock from that island. At first one would naturally wonder how it was possible for these arboreal snails to cross such a body of ocean and become established on the new land. Both eggs and snails sink at once in water; no bird could possibly carry either across in its beak or on its body; neither could eggs or snails be transported through the air by hurricanes. The main current of the Gulf Stream which sweeps up past the western end of the great island turns to the west as it enters the Gulf of Mexico and slowly passes around its deep central basin. It is probable that under ordinary circumstances weeks would elapse before any floating object that passed into this great vortex through the Yucatan Channel would emerge and enter the Florida Strait, and in that time any *Liguus* which might be carried over this course attached to limbs or trunks of floating trees would be sure to be washed off and perish. It would seem, then, that every means of transportation for these snails was shut out and that it would be impossible for them to migrate in any way from the great island to Florida. But when we once fully understand all the conditions it appears as though nature had specially arranged everything not only to make this voyage and colonization possible but absolutely feasible and that there have been a considerable number of successful migrations and colonizations.

The *Liguus* never voluntarily leave the trees on which they live except at the time when they go down to lay their eggs or make the migrations across the country for the purpose of founding new colonies, which I shall later describe. During the dry season, from November to May, in Haiti, Cuba, and Florida, these snails throw out a gummy substance which hardens and attaches the shells so firmly to the trees on which they live that they will often break without letting go. At this period of aestivation, as it is called, the

animal becomes dormant, much as do those of northern countries during hibernation, only the organs do not so completely cease to function. Before the beginning of the rainy season, sometimes as early as April, the snails dissolve or let go from this epiphragm, as the gummy substance is called, and become active. Sometimes in winter if there is rain and especially if the weather is warm they do this but make an epiphragm and become dormant if it becomes dry and cool again.

They live, for the most part, on smooth trees, but sometimes they are found on those with rough bark, even live oaks, and in our State, only in its extreme lower part. Although almost wholly confined to the drier hammocks in Florida I have collected them in our brackish and fresh-water swamps, in the former on the tropical buttonwoods (*Conocarpus*) and on cypress trees in the latter. In very rare cases they have been seen on Caribbean pine trees at the edge of hammocks. Their food is the confervoid growth which is found on the bark and possibly the leaves of the trees which they inhabit. Sometimes, especially during rain, I have seen them clinging to the under surfaces of leaves though this was not for the purpose of keeping dry. During the warm season they freely copulate, and as they are hermaphrodites it is probable that nearly all the individuals become pregnant.

In the warm or rainy season from May till November tremendous showers fall in northern Cuba and trees in stream valleys bearing colonies of *Liguus* may be washed out and swiftly borne down on the current of the mountain torrents and into the sea. It is probable that most of our *Liguus* stock is derived from the northern slope of western Cuba, and such trees thrown into the ocean are caught by a small current that leaves the main stream which passes up the Yucatan Channel, and this smaller flow hugs close to the northwest shore of the great island. Farther on it joins the Gulf Stream after the latter has passed entirely around the deeper part of the Gulf of Mexico, the junction taking place in the Florida Strait, the whole great current moving to the east and northeast and sweeping against the lower part of Florida. This current in the strait moves onward ordinarily at the rate of from 2 to 4 miles an hour, much depending on the direction and force of the wind. In time of hurricanes with wind and heavy rain from the west or southwest the speed of this ocean river would be greatly accelerated, and trees bearing *Liguus* might easily be borne from northwest Cuba to the keys in 48 hours.

It is probable that some of the snails which adhere to the trees on which they live may be carried high and dry on limbs during a trip of considerable duration and distance as they are making this passage, but even if they do become immersed for quite a length of time I feel sure no damage would come to them. At one time I put a

lot of over 30 active *Liguus* into a vessel of water, weighting them down with a piece of board so that all were kept completely submerged for 30 consecutive hours, and when released every one of them crawled away as though nothing had happened. All were clinging to the board when they were taken out.

During the rainy season the wind in the Florida Strait blows for the most part from the southeast, and this drives any drifting material diagonally across the current toward the Florida Keys and the southeast mainland. A slight, irregular flow of water takes place along this part of the mainland and the keys in a direction opposite to that taken by the Gulf Stream. This slow movement keeps close in to the shore and would tend to carry drift to the south and west, even in some cases that which had passed for a considerable distance along the main current, thus helping to distribute material carrying *Liguus* along our southeastern shores. The greater part of the cold Labrador current goes under the Gulf Stream above Miami, and it is mixed up in this vicinity, so that it sometimes drifts to the north and again to the south. It is quite probable that the feeble current running westerly among the keys is the last vestige of this cold river.

Nearly all the inner shore line of the keys and the southeastern mainland of Florida is fringed with a growth of mangroves, but on the side fronting the open sea there are sandy or rocky beaches. The trees growing in "the mangrove" usually stand in mud or very shallow water; and wherever they grow conditions are not favorable for the landing of tree snails because, so far as I have been able to observe, they never crawl over wet mud. However, during September, October, and November we have unusually high tides all along our lower coast, then they sometimes reach an elevation of 2 or more feet above the ordinary tide. In many cases *Liguus* inhabit dead trees or limbs, and such might easily be broken up during their journey down the Cuban streams or while making the sea crossing before reaching Florida. I have no doubt that in some cases these snails reach our shores on comparatively small pieces of floating timber, and these could easily drift in among the mangrove roots, where they are not too crowded, during excessively high tides and be landed on what is ordinarily high and dry ground. If such a landing happens to be made in the edge of a hammock, the snails could crawl off and become denizens of the United States without any formality. Of course, during hurricanes the sea may be driven over the highest land on our lower coast, and it is most likely that the greater part of the *Liguus* have been landed and established in Florida during such storms. At one time, since I resided here, the wind during one of these storms drove the sea entirely over Elliotts and Largo Keys and far out on the mainland of Dade County.

There are authentic records of other even greater tidal waves in lower Florida.

Without a doubt this process of enforced migration began as soon as the *Liguus* spread over the island of Cuba, perhaps back in Miocene or Pliocene times, but it is probable that no region existed to the northward suitable for them to live in. Certainly if any colonies of these snails existed in any part of what is now Florida before the Glacial epoch they were destroyed by its cold, for they are tropical and can not stand hard freezing.

A period of subsidence occurred for the State of Florida during early or middle Pleistocene, and nearly all the eastern part of it and all the lower end to just north of the Caloosahatchee River were carried below sea level. A great bed of oolitic material, the Key West limestone, was deposited over the area now occupied by the Lower Keys. Another very similar set of beds was laid down along the southeast part of what is now the mainland—the Miami limestone—and a third on the southwest coast called the Lossmans River limestone. A set of beds was formed in what is now the Everglades, at first doubtless marine, then brackish, and finally fresh water. It is probable that a coral reef, which afterwards became the Upper Florida Keys began to develop during this subsidence, and it reached from a short distance south of Cape Florida in a curved line to what is now known as Newfound Harbor Keys, just south of Ramrod Key, thus lapping over onto what is now the Lower Keys for a distance of perhaps 5 miles. This was followed by an elevation during which the land was probably raised to about the same height as at present. The great bed of Key West limestone became a single island, reaching from east of Johnson Keys to and including Key West and from the Gulf of Mexico on the north to the Florida Strait on the south. The sea began to form a low, broad shore elevation just within what is now the southeast coast of the mainland from somewhere near Fort Lauderdale to the south, then southwest, west, and again southwest to near Whitewater Bay. This consisted of low ridges which formed one after another as the sea retreated, leaving flats and shallow lagoons between, and in these marine mollusks and other animals lived and died undisturbed. Later this became a soft oolitic limestone.

A great variety of seeds of tropical trees, shrubs, and plants was carried by the Gulf Stream, a few possibly by migrating birds, and some lighter ones by the wind and landed on the large southwest island as soon as it was high and dry above the tide, and at once a dense hammock growth was formed over much of the higher parts of it. Seeds of the Caribbean pine (*Pinus caribaea*) were probably blown across from Cuba and forests established on some of it and

on the rocky ridge of the lower mainland. Hammocks began to be developed in protected places on this ridge, and conditions were right for the establishment of colonies of *Liguus* on the soil of the United States.

We can not tell whether the first successful settlement of these snails was made on the great southwest key or southeast mainland, but quite likely on the former. A gravid specimen of a form close to our present *graphicus* clinging to the tree on which it had made its home was thrown up on this island, either by an unusually high tide or during a hurricane. It probably came from somewhere in the neighborhood of Cabanas, about 40 miles west of Habana, where Dr. Carlos de la Torre, the late John B. Henderson, George H. Clapp, and the writer found a form of *Liguus* in considerable numbers that has nearly all the characters of that beautiful snail. It is, however, smaller, is a richer yellow, is not quite so porcellaneous, and is a little less flamed on the spire. I have little doubt that our *graphicus* sprang from the same stock as the small Cuban form did.

The newly arrived snail multiplied and probably spread over most of the drier parts of the island, for at least recognizable fragments of it has been found on most of the keys where there is high land. Certain forms among its progeny seem to have partially lost their coloring, and one of these which Say called *solidus* has a broad, faint, spiral yellowish band above the periphery and another on the base. A second somewhat thin variety which has delicate coloring Pilsbry has named *solidulus*. This is whitish or cream colored with one or two faint yellowish narrow, spiral lines at the periphery, another at the suture, and sometimes a broad one on the base. Some of the shells which are doubtless of this variety have two or more narrow greenish or bronzy spiral lines on the last whorl, and others scarcely show a trace of banding. A shell from Ramrod Key of the lower islands is almost pure white throughout, and a very solid form which I found on Big Pine Key is ivory white, with a single narrow, bronzy peripheral line and a decidedly truncated columella to which I gave the subspecific name of *crassus*. Mr. John B. Henderson had specimens in his collection from Key West which I refer to this. I feel sure that if a large collection of *solidus* could have been made from the Lower Keys it would have shown a considerable amount of variation in coloring.

Reeve bestowed the name *Achatina picta* on a form of *solidus* which has a pale, ashy yellow ground pattern with longitudinal bluish smears and a double row of squarish brown spots at the periphery and sutures, and he gave Cuba as a locality for his shell. There is a specimen in the collection of the United States National Museum with the same locality given, and many years ago I re-

ceived a fine shell of this form in an exchange from A. G. Wetherby labeled "*Achatina fasciata*, Cuba." I only know of two authentic Floridian specimens of this subspecies, one of which is in the collection of the Academy of Natural Sciences of Philadelphia and was collected by Dr. H. A. Pilsbry on Big Pine Key when on a trip to the Lower Keys with the writer in 1907. The other is a somewhat worn shell, but showing the colors perfectly, that I found on the same island in the village of Big Pine a few years later. D'Orbigny figures a shell in his Atlas which he credits to Cuba and which no doubt came from that island which bears some resemblance to *pictus*, but it is not that. I found a very similar shell at Luis Lazo in western Cuba that I believe is a hybrid between some form of *fasciatus* and *solidus*.

It seems a little strange that this snail (*pictus*) should be reported from Cuba at least three times if it was never found there. I am very much inclined to think that it has actually been collected in that island as well as in Florida and that it crossed the strait and landed on Big Pine Key since the dismemberment of the large island, and so short a time ago that it has not changed any of its characters in the least. There is comparatively deep and open water close up to the big hammock in which both the specimens of *pictus* were found on this island.

It is probable that not more than two forms of *Liguus* ever landed on the great island, although it is nearer to Cuba than any other part of Florida, and it certainly was clothed with hammock at an early date. The reason for this paucity is perhaps the fact that the Lower Keys lie almost directly across the Florida Strait from the western part of Cuba, and the strong eastward-flowing Gulf Stream would naturally carry any drifting material past them.

No sooner was the great western island, the original of the present Lower Keys, formed than the forces of nature began to destroy it. Every winter several storms called "northers" sweep down from the northwest across the Gulf of Mexico, the wind often blowing to 30 or even 50 miles an hour, throwing the water of this great inland sea with tremendous force against the land of this region and cutting into it all along its entire northern exposure. As a consequence its northern outline is far more ragged than the southern. Not only this but the water was driven with such force that it was crowded completely through the porous foundation of the island from north-northwest to south southeast so that it came out in strong streams on the south side into the Florida Strait. This water soon formed channels through the loosely compacted rock in the eastern part of the great island, and these were enlarged by scouring and the action of the carbon dioxide in it. Later the weakened roofs fell in so that open streams reached entirely across, for the most part in exactly the

direction of the wind during these storms. It is probable that the rock in the western end of this former island is of a solidier type than that of its eastern part, hence the water was not driven through to any considerable extent but it entered everywhere by seepage and has eroded and dissolved it into a most complicated archipelago. I feel certain that a *Liguus*, the forerunner of the forms we have found on these Lower Keys, reached the big island, became established, and spread over the entire region and that it broke up into several varieties which pretty well occupied the whole area before the dismemberment took place.

A thin, glassy, inflated form of *crenatus* was cast ashore on the elevated hammock near Fort Lauderdale, no doubt an early migrant from Cuba to our shores. Later the sea threw up a great sandy bar or bank a few miles to the east of this forest, and the intervening space has been filled with a mangrove swamp. The *Liguus* has been carried down and established on this bank where I found it at the New River mouth and for a couple of miles to the northward. This colony of *septentrionalis*, as Pilsbry has aptly called it, is the farthest north of any in the United States. The form has spread south of New River, it has crossed Little River, and in a hammock just below the mouth of that stream I found nearly pure individuals. Near Arch Creek it has hybridized with one of the forms of *fasciatus*, the shells having exactly the shape, markings, and texture of *septentrionalis* but a pink axial region. I have shells from the town of Jamaica in Cuba that are very close to this.

It is probable that at least four forms of *Liguus* that drifted from Cuba became established at the great Miami hammock. According to the Report of the State Geological Survey some of this land is elevated to a height of 30 feet above sea level, and it is most likely the highest on the southeast coast. It was probably above the sea and was dry land before any other part of this general region and has had a longer time in which it could be colonized by snails. These forms I have called *miamiensis*, *livingstoni*, *mosieri*, and *eburneus*, the first two belonging to *fasciatus*, the latter two to *crenatus*, and none of them inhabits the Upper Keys. *L. miamiensis* is doubtless a hybrid between a form near *costaneozonatus* and probably a typical *fasciatus*, the earlier whorls having a broad, more or less broken brown band and the last whorl a pattern of spiral lines, the two coming together abruptly. I have shells from Cuba which show similar characters. This form ranges from Ojus to a considerable distance south of Miami. The form *livingstoni* is a small *fasciatus* usually lacking the color pattern on the upper spire, but I have a shell from Luis Lazo, in Pinar del Rio, that is exceedingly close to it in which the color pattern has almost vanished. It is found from Fort Lauderdale south to Long Pine Key. I have large shells of *mosieri*

from Miami that are almost identical with a specimen from Mount Guajaibon in northwestern Cuba, they being larger than the latter. It is found over nearly the entire rocky ridge of southeast Florida. *Eburneus* is a fine subspecies usually large and solid, somewhat porcellanous, and nearly always pure white throughout. It is almost perfectly mimicked by a shell I collected in western Cuba. It does not extend north of the Miami River but goes south to Long Pine Key in the Everglades.

Thirteen subspecies of *Liguus* inhabit this great Miami hammock—*eburneus*, *mosieri*, *luteus*, *cingulatus*, *marmoratus*, *livingstoni*, *ornatus*, *miamiensis*, *elegans*, *roseatus*, *testudineus*, *castaneus*, and *castaneozonatus*—a considerably greater variety than is found in any other Floridian locality. *Luteus* occurs from Dania to Long Pine Key and in the former region as well as at Vaca is rather solid and bright colored, but in the lower Dade is thinner and lighter. It is the first form to be colonized in the incipient hammocks, and at almost every sink that has a live oak and a little scrub it will be found, while *castaneozonatus* is the second migrant. *Marmoratus* is a very variable snail with a wide distribution, and specimens found by me in the Miami hammock are very close to those from Key Vaca of Chokoloskee. A form of this has recently been found at Pinecrest, 35 miles west of Miami in the Everglades. I have no doubt but that *testudineus*, *castaneus*, and *versicolor* are hybrids between this and forms of *fasciatus*. The subspecies *elegans* was discovered on a small key in the southern Everglades, which was occupied exclusively by it and *roseatus*, and it is close to shells I collected in northwestern Cuba. It occurs occasionally along the rock ridge as far north as Arch Creek, usually in a pure form and always having the peculiar brownish flecks on the upper spire.

Two peculiar forms of *crenatus* are confined to the southwest mainland, where they have a limited distribution—*lossmanicus* and *capensis*. The former is dull colored, whitish, sometimes with narrow spiral greenish lines, and the whorls are usually well rounded. The form *capensis* is elongated, and solid with flattened whorls occupying Northwest Cape exclusively and found rarely elsewhere in the cape region. It is probable that both are recent arrivals from Cuba, and they may have drifted through the Bahia Honda Channel. The fact of their limited distribution is evidence in the direction of their recent arrival.

It is probable that the land of the Cape Sable region is very recent, one of the latest additions to our territory. The area covered by the three points, Northwest, Middle, and East Capes, and the region for some distance back of them is sandy, but it was built up over an old mangrove swamp. Back of this sandy land there is a brackish swamp, and still farther back a considerable prairie, while at the

juncture of the two latter is a line of hammocks. The entire inner country lies only just above high tide, and whenever during a hurricane the wind becomes westerly the water from the Gulf of Mexico is driven in to Florida Bay and the region to the north of Sable with great force. As the chain of Florida Keys acts as a barrier against this water passing to the eastward it is dammed up and forced over the south shore, the Sable and southwest coast areas, sometimes covering the highest land to a depth of several feet. Before there were any breaks in this upper chain of islands the dam was almost complete, and doubtless the depth of water became much deeper than at present. As there is a great deal of swamp in this territory, *Liguus* can not progress from hammock to hammock as they do through the high pine woods for, as I have said, they never crawl over wet mud. There are, however, both *Liguus* and *Oxystyla* distributed abundantly throughout this whole area wherever there are suitable hammocks, but they are scattered absolutely hit and miss. At Northwest Cape only *capensis* is found, while in a little hammock just north of Middle Cape Dr. Edward Mercer and I got *lossmanicus*, *castaneozonatus*, with hybrids between the two, and a single, fine *marmoratus*. At Middle and East Capes there is quite a variety of forms, and this is true of the line of hammocks between the prairie and the brackish swamp. In one of these would be found an *Oxystyla*, in the next perhaps a single form of *Liguus*, in a third absolutely nothing, and in the next both *Liguus* and *Oxystyla*. Yet in some cases these bits of woods are only a few rods apart. The explanation of this is, I believe, that trees and limbs with snails are torn off by the fury of the hurricanes in this region, probably carried along by the high water and landed on some hammock. One such piece of forest might receive a *Liguus*, another an *Oxystyla*, another both, and a fourth none. The ground immediately in front of this row of hammocks is always swampy; that in the rear is wet in the rainy season and dry in the cool part of the year. The snails can not crawl over it in summer, and in winter they are fast to the trees. Some of the cape forms may have arrived during the first elevation, but most came at the second.

Since the above was written a great highway, the Tamiami Trail, has been opened from Miami west through the Everglades, and at a place on this called Pinecrest, midway across the State and 40 miles from its south end, Mr. Joseph Farnham and Mr. Richard Deckert have found great numbers of *Liguus*. Many of these are hybrids, but they are generally rather closely related to the forms found on Long Pine Key in the south part of the Glades. It is probable that during one of the late minor subsidences this region was somewhat lower than now and that a strong tidal wave may have carried the

progenitors of these forms from Long Pine Key and landed them here.

It is probable that at the time of the first elevation the reef of which the Upper Keys was formed was considerably developed and raised to the surface of the sea or even somewhat above it in places, but I doubt if it was clothed with hammock forest or inhabited by land snails. The flora is composed of tropical plants and has been almost wholly derived from Cuba, but it is comparatively poor, having scarcely half as many such species as the Lower Keys and nothing like as many as the southeast mainland, and this fact would prove that it is much younger than either of the last-mentioned areas.

Then there was a second period of subsidence during which the land went down until the sea washed into the present bluffs at Coconut Grove and Miami, eroding them in places into fantastic forms. At Little River the depression amounted to some 7 feet, while at Big Pine Key it was about 3 feet.

An elevation followed during which the land was raised perhaps to a few feet higher than it is at present. The Upper Keys were elevated until they probably formed an unbroken chain or single island. The sea attacked the reef, tearing it to pieces, scattering the fragments and grinding them into sand, then cementing the wreck firmly together and building it up into a solid, continuous island. This great barrier for a long time prevented floating material from landing on the mainland back of it, but it became more or less covered with hammock forest and provided a home for such *Liguus* as drifted in from Cuba. Several forms, either *roseatus*, *castaneo-zonatus*, *vacaensis*, *lineolatus*, and perhaps *marmoratus* or their immediate progenitors, drifted in from Cuba and became established long enough ago that they spread practically throughout the entire length of the long, curving island. This was the heyday of the Upper Keys, the period of their greatest development and glory. A broad, irregular land bridge reached from the region of the Matecumbes across to the mainland from Joe Kemps Key for 12 or 15 miles to the eastward. In places this was swamp or shallow lagoon, but there was continuous hammock-covered land, and over this migrated a considerable variety of tropical vegetation from the keys; in fact most of the flora of the south and southwest coasts of the mainland was derived from the Upper Keys in this way. This flora differs considerably from that of the rocky ridge along the southeastern mainland. It is nearly all tropical, while that of the ridge is mixed—West Indian and warm temperate—the latter part being derived from the northward. The reason for this is that the Everglades stretches, and since the first elevation has stretched, in a broad, unbroken area from near Whitewater Bay eastward and northeastward to Cutler, forming an effectual barrier against the

passage of dry-land plants and to a considerable extent the migration of snails. *Liguus* could only cross this great marsh during a time when the sea was driven in over it by hurricanes and then on floating timber.

During the time of the second elevation there was probably an almost continuous hammock along much of the south shore of the mainland; in fact a considerable amount still remains. The *Liguus castaneozonatus*, *vacaensis*, *lineolatus*, *roseatus*, and *marmoratus* crossed over from the keys and became established on the south and southwest parts of the mainland. By and by the sea began to seriously gnaw away at the great coral island. High tides occur on one side at different times from what they do on the other, and I have seen at low tide on one side of one of these coral keys many streams of water passing through, from a tiny trickle to those of the size of small rivers. Soon the carbon dioxide in the water ate the rock away until the weakened roof fell and later an open channel formed which cut the island in two. This action, aided by the fury of the sea when driven in by storms, has been continued until this once greatly elongated island has been cut into more than 30 islets and islands, each high enough to bear upland hammock, besides a vast number that are only clothed with mangroves. Of course when a key was cut in two it checked the passage of the *Liguus* from one island to the other, and we can form some idea of the time of arrival of the snails by their distribution. The subspecies *matecumbiensis* did not arrive until Upper Matecumbe was cut off from the keys to the north and south of it, for we have never found it on any other of these islands. But it came in time to cross the land bridge, for we find it one of the most abundant of the tree snails of the Flamingo region. *Oxystyla floridensis*, which inhabits the keys from Largo southwestward, crossed this bridge and is very abundant in the Cape Sable area; but *O. reses*, which inhabits the keys from Key West to Vaca, apparently has not passed any farther up them nor crossed to the mainland. A beautiful form, *subcrenatus*, was common in the center of the upper chain from probably Largo to Grassy Keys. The subspecies *elliottensis* has its metropolis on the island for which it is named but has been found on Old Rhodes and possibly upper Largo. It was a late arrival and probably was kept from an extensive distribution because of the cross-channels.

Four subspecies of *Liguus* which inhabit almost the entire range of the Upper Keys—*castaneozonatus*, *roseatus*, *marmoratus*, and *luteus*—are also found on the mainland on the rocky southeastern ridge, although a tract of Everglades and a series of shallow sounds separate the two regions. During time of hurricanes when the sea is driven against southeast Florida with tremendous force the entire chain of islands may be overflowed and water driven in until it covers

the lower parts of the rocky mainland ridge. At such times many limbs and trees on these keys are torn off or uprooted and with their load of *Liguus* may be easily carried across and landed on the higher mainland. There it is easy for the snails to crawl off and get into the hammocks, where they are soon established.

The last general earth movement in lower Florida was a slight subsidence which may be continuing yet in places and of which there is abundant and widespread evidence. In the Shark River region hundreds of acres of what must have been land are to-day under a very shallow sheet of water in which littoral forest grows thickly and in the same general area and in Biscayne Bay are dead trunks of large mangroves that probably started growth on the land, but have been killed by the slight subsidence. The marly hammocks along the south coast are tumbling into the sea and the general chain of keys is being rapidly destroyed by the encroaching ocean. The great land bridge has been reduced to low islets and shoals. This subsistence has had a marked effect on the *Liguus* of the upper islands.

The distribution of the *Liguus* on the Upper Keys is amazing, and for a long time I was utterly unable to understand how it came about. Seven subspecies—*castaneozonatus*, *roseatus*, *lineolatus*, *vacaensis*, *marmoratus*, *luteus*, and *subcrenatus*—are found living on the upper and lower ends of the chain but all save *lineolatus* and *subcrenatus* are entirely absent from the central part of it. The subspecies *subcrenatus* now inhabits Lower Matecumbe and has probably lived in the islands to the southwest as far as Grassy, perhaps to Vaca, while *castaneozonatus* and *luteus* occupy the northern end of Upper Matecumbe and the islands to the northwest. Long Key, farther down in the chain though a large island with some dry, hammock-covered land, seems to be absolutely lacking in *Liguus*. Yet on Lower Matecumbe, Lignumvitae, the extreme lower end of Upper Matecumbe and Indian Key, lying in the exact region where five of the forms I have mentioned are absent, we find no less than four tolerably well-defined subspecies of *solidus*, a species only found elsewhere in the United States on the Lower Keys. Why are these seven forms present in the ends of the chain and all but two absent from the center, and why should they be replaced here by a species of the lower islands? Why is Long Key without *Liguus* when it seems to be perfectly adapted for their growth?

I feel sure that during the period of greatest elevation the entire set of the Upper Keys from near Cape Florida to and including the Vaca group was one great island, so high and well clothed with hammock that the seven forms I have mentioned, which were early arrivals, became distributed throughout the whole. Then at the time of the last general subsidence the middle of this chain went down just

enough to change the dry-land hammock into mangrove swamp, and it needed only a slight depression to do this. Five of the forms—*castaneozonatus*, *roseatus*, *luteus*, *marmoratus*, and *vacaensis*—were drowned out on Lower Matecumbe, but *subcrenatus* and *lineolatus* survived, probably on a bit of hammock at the upper end of the island, as this is a little higher than the rest of it. The snails were drowned on the southwest end of Upper Matecumbe, which is slightly lower than its northeastern part and is now nearly all swamp with only here and there dry land. Long Key was carried down just enough to drown out its *Liguus*. It is probable that a very slight upward oscillation of this region since has made the latter island dry enough for high hammock growth as a foot of elevation would change swamp to dry land. But no *Liguus* have landed on it since.

During this last slight elevation of the mid chain a gravid specimen of the variety *graphicus* was landed (on drift from one of the Lower Keys), probably on Lower Matecumbe, where it quickly became established and soon began to vary. Two of its forms, *lignumvitae* and *simpsoni* are now living on the near-by Lignumvitae Key, a mere dot of land just inside the regular line of the chain and separated from Lower Matecumbe by a mud flat a little more than a half mile wide. Another form which I have called *delicatus* is found on Lower Matecumbe and on a small bit of hammock in the swamp of the lower end of the upper island; also it was found by Wurdemann long ago on Indian Key, another mere point about half a mile outside the line of the regular chain and just off the lower key. I am inclined to believe that these outlying *Liguus* reached Lignumvitae, Upper Matecumbe, and Indian Keys by drifting during storms.

In a part of Lower Matecumbe, where cross currents have eroded and lowered the surface until it is no longer dry land, there is a small hammock in which I found a fourth form of *solidus*. The shells are large, thin, of a glassy rather than porcellaneous texture, the ground color being a pale yellowish gray. They have the longitudinal smears and a brownish peripheral band, and along this and the sutures is a double row of squarish spots, while the entire axial region is white. Because of its resemblance to *pictus* I have called it *pseudopictus*. Apparently it has rather recently developed in this isolated hammock, and I found a few partly intermediate shells. I have no doubt that it is the latest form of the genus to develop in Florida.

The species *solidus* seems to vary very easily and apparently has broken into many forms. I found several interesting variations or perhaps hybrids of what may be this species and some other near Cabanas, Cuba, and I feel sure that before our hammocks were destroyed in Florida there were several variations. I found shells on

Lignumvitae Key which are so close to *graphicus* that it would puzzle an expert to tell them apart, but there were intermediates between them and *lignumvitae*. While the porcellanous structure is one of the chief characters of what we call *solidus*, it is almost absent in *pseudopictus*, and the axial region in the species may vary from almost dark purple to pure white.

It may seem that I have recorded a large number of minor elevations and depressions, mere oscillations, in lower Florida since the first appearance of the land, and I feel sure that there have been, as for most of them there is still in existence evidence in the form of raised beaches, eroded bluffs, or sunken forests. Samuel Sanford corroborates this statement and says that in places they have been rapid enough to be proved by human records.¹

Almost all of lower Florida is very flat, and it rises but slightly above sea level. The same authority I have just quoted remarks, on page 189 of this second report, that "A difference of 2 feet in water level means the difference between shallow lake and dry land for hundreds of square miles." So also in the immediate vicinity of the sea a subsidence of less than a foot might mean mangrove swamp and a corresponding elevation land covered with *Liguus*-bearing hammock.

But the vertical movements were only slight from the first appearance of land in this region until now. At no time has there been a subsidence so great that the large lower island or the rocky mainland has been drowned out nor an elevation sufficient to make dry land of the bays along the southeast coast of the mainland, for in that case the warm temperate flora of the rocky ridge would have crossed over to the Upper Keys, and had there been a drown out the distribution of our plants and *Liguus* would have been very different now from what they are. Since the first great Pleistocene elevation I do not believe that the change of level has amounted to 15 feet.

The colonization of *Liguus* on the mainland of Florida came about under quite different circumstances from those of Cuba or most of our keys. In both of the latter areas there was a practically continuous growth of tropical forest which was exactly fitted for a home for these snails. They are hermaphrodites, and during their period of activity it is probable that most of them copulate and become gravid. At this time a considerable number of individuals come down from the trees on which they make their homes, and instead of depositing their eggs in the ground near them they obey a call to form a new colony. They travel directly away, probably going in a reasonably straight direction, and whenever they are satisfied they stop, dig out a shallow excavation among the leaves and trash, lay their eggs, cover them, and find a near-by tree for a new home. There is no

¹ Second Report Florida Geological Survey, p. 180.

special risk or hardship about this, for the snail never leaves the sheltering hammock; it can stop and deposit eggs whenever it likes; there is an abundance of food all around it.

A large part of the lower Florida mainland, however, is covered with an open growth of Caribbean pines, and such a region is hostile to the *Liguus*. There is practically no shelter; there is little or no food; in places where the floor of the forest is sandy it is impossible for them to progress unless they can crawl from plant to plant above it. Only here and there at intervals is there a hammock, and although the snails have a certain amount of vision yet it is probably impossible for them to distinguish one from the pineland. Yet these wanderers obey the instinct for founding colonies which was begotten during the thousands of generations that preceeded them and boldly strike out into the pine woods in order that they may reach another hammock and plant their race in a new territory.

At my home I once observed one of these snails which had doubtless left my near-by hammock and was attempting to work its way out into the open pine woods. We had rains for several days in succession, and during this time it moved away from the hammock at the rate of about 25 feet a day, and I kept close watch and set stakes to mark its onward passage. This one and others I have noticed crawled along the stems of small shrubs or grass, over fallen logs, or anything that made a firm pathway. When the weather was dry and the sun shone the *Liguus* attached itself to something and did not attempt to go on until it rained again. I kept track of this specimen for several days, noting that it persistently worked away from my hammock and out into the uncharted pine woods. I have on a few occasions found them in the open forest at a long distance from any hammock and in rather numerous cases the dead shells which probably testified to the disaster in the way of exhaustion that finally overtook them.

The migration is of course absolutely hit and miss, as no snail can know when it starts on such a journey that a hammock is in front of it. No doubt in cases where a number of hammocks are scattered through an area of pine forest a crawling *Liguus* might pass by one and, continuing on, enter another not far away. So in any general region a hammock may have a form that is absent from another that is only a few rods away; one may have several subspecies and another near by only two or three, even a single one, or rarely none at all. One of our leading botanists believes that the hammocks formerly covered most of the lower part of Florida and that the pine trees are late immigrants that are spreading and taking possession of the country, but if this were true we should find the remaining hammock portion occupied by practically the same forms of *Liguus* throughout.

There is another way by which, to a limited extent, it is probable that the *Liguus* may pass from one hammock to another and become established. Mr. Charles Mosier informs me that he has on several occasions seen crows flying with these snails in their beaks. It is a

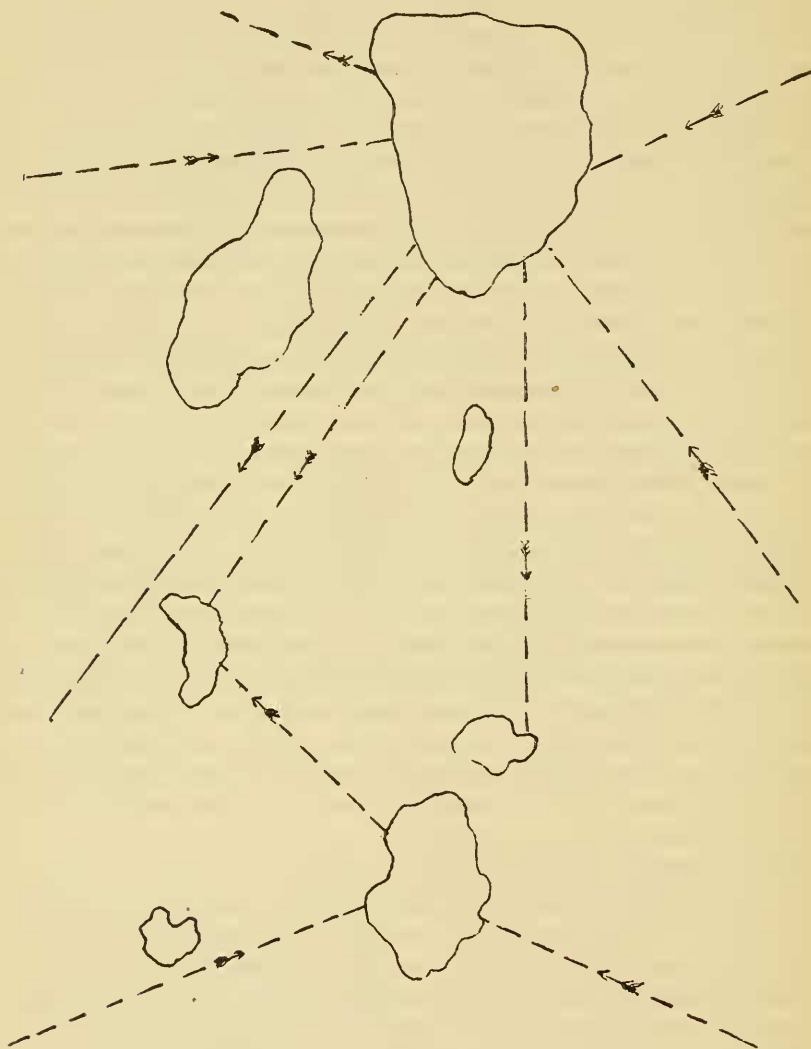


FIG. 1.—DIAGRAM ILLUSTRATING THE DISTRIBUTION AND MIGRATION OF *LIGUUS* IN FLORIDA. THE OPEN SPACES ARE PINE WOODS; THOSE INCLOSED IN LINES, HAMMOCKS. DOTTED LINES SHOW MIGRATION TO AND FROM HAMMOCKS. SOME BITS OF FOREST ARE REACHED BY SEVERAL; OTHERS ARE ENTIRELY MISSED

well-known fact that these and other large birds frequently prey on *Liguus* and other arboreal snails, and I have seen the ground in hammocks strewn with their broken shells. It is not unlikely that these birds may occasionally pick from a tree one of these snails and

carry it away with it, just as they carry away large seeds. The *Liguus* when disturbed throw out a quantity of a mucilaginous substance which is very slippery, and in such a case it might easily happen that the snail would slip and fall to the ground during the flight of the bird. If it should fall in a hammock in an uninjured condition there would be nothing to hinder it from making its home there, and if gravid laying its eggs and establishing a colony. Such distribution would be essentially the same as if the snails crawled through the pine forest.

As the changes of land level and the movements of the *Liguus* have been somewhat complicated I will briefly recapitulate. These snails in Cuba are closely related to our forms and without a doubt are their ancestors, often scarcely removed varietally. I am sure that the close resemblance of a number of forms from the great island to those of our State are not accidental but that they indicate very close relationship. I have actually seen snails there that are very much like *graphicus*, *livingstoni*, *miamiensis*, *septentrionalis*, *elegans*, *subcrenatus*, *eburneus*, *castaneozonatus*, and *mosieri*, and I have no doubt that there are other contiguous forms.

Trees in which these Cuban snails grew were washed out, carried with their living loads down the torrents into the sea and swept by current or the force of hurricanes along the Florida Strait; the southeast winds of that region would bear them on to our lower shores where, because of hurricane tidal waves or very high autumn tides, they would be landed high and dry on our shores where they could form colonies.

There was a great subsidence of Florida during early or mid-Pleistocene time, and the region now occupied by our Lower Keys and the southeastern part of our mainland received a deposit of oolitic limy beds. A long, curving coral reef began to grow along the south and southeast part of the State from near Cape Florida to the south side of Ramrod Key. During the elevation that followed, the sea swept this oolitic material up along our southeast coast and formed a series of low ridges as the shore retreated and when this land was high enough it became covered with Caribbean pines whose seeds were wind blown from Cuba. A single great island was raised covering the area of the present Lower Keys and seeds from west Cuba, for the most part, were borne in on the Gulf Stream and the large island partly planted with hammock growth. Two large hammocks were formed on what was then the open coast, one at Fort Lauderdale, the other at Miami.

A gravid snail much like our *Liguus solidus graphicus* drifted in from near Cabanas, Cuba, was landed on the lower island and became established in the hammock, spreading over the greater part of the area and breaking into several varieties before the land was

cut up into islets. One form of *crenatus* landed at Lauderdale and spread southward; several came to the great Miami forest and, as the land was raised and developed, hammocks spread southward and southwestward along the low, rocky ridge. It is doubtful whether the reef became high enough for hammock and snails to develop on it at this time, but the sea no doubt attacked and spread it.

During a subsidence following, the coral reef probably grew up as fast as the land went down. The water of the Gulf of Mexico driven by furious northers began to erode the north shore of the great island and was driven in places entirely through it, finally cutting up a considerable part of it into islands running exactly in the direction of the wind. Sea water entered what was probably solid rock at the west end and ate it into a complicated archipelago. *Liguus solidus pictus*, found only on Big Pine Key, is perhaps a recent arrival coming long after the great island was dismembered.

When the land was elevated again it reached a higher level than now, and as it rose the sea kept tearing at the reef and consolidating it until at the time of highest land it was no doubt a single long curving island with continuous hammock and a number of *Liguus* which came from Cuba were thrown on it and had time to spread throughout its length. At this time there was a broad land bridge across from the Matacumbes to the south mainland. The flora of the Upper Keys is tropical but meager in species, and this would prove that the chain was much younger than the southeast mainland or the Lower Keys, which have a far richer tropical flora.

Many species of these West Indian plants crossed on the continuous hammock of the old bridge and now constitute almost the entire flora of the south shore and southwest coast. Through this hammock *Liguus marmoratus*, *vacaensis*, *roseatus*, *lineolatus*, *castaneozonatus*, and no doubt *Oxystyla floridensis* crossed to the mainland and became established there, perhaps during the time when there was the highest land elevation. *Matecumbiensis* landed on the key it was named for after the dismemberment of the Upper Keys but before the destruction of the bridge, and crossed. Dry-land connection between the south shore and the rocky ridge was prevented by the Everglades which stretched from Cutler to White-water Bay and had done so from the first. Several forms belonging to the Upper Keys were carried to the southeastern mainland across the bays by hurricane agency. The Cape Sable region is very recent, the capes being sand washed up on an old mangrove swamp. The sea is thrown in upon that region by hurricanes with terrific force, and as the water is driven into Florida Bay and is prevented from flowing south by the keys it overflows the Sable and southern shore regions and *Liguus* and *Oxystyles* are distributed hit and miss.

Capensis and *lossmanicus* may be recent arrivals through the Bahia Honda Channel.

Seven subspecies of *Liguus* inhabit both upper and lower ends of the upper chain of keys but all save *subcrenatus* and *lineolatus* are totally missing in the center of the chain, and they are replaced by forms of *solidus*, which appear to have developed from *graphicus*. Long Key, which has good hammock, seems to have no *Liguus*. During the last general subsidence the Upper Keys went down enough that all the *Liguus* in the center of the chain save *subcrenatus* and *lineolatus* were drowned out, and these subspecies probably survived on a bit of dry land at the northeast and higher end of Lower Matecumbe. All the snails of Long Key were drowned and no others have reached it since. During a local but slight elevation of the center of these keys a gravid *graphicus* landed on the first-named island, where it multiplied and broke into variations, some of which drifted to some of the near-by islets.

In Cuba and the Florida Keys the *Liguus* have for ages occasionally come down from the trees when gravid and, obeying an instinct for founding new colonies, have wandered off into the forest, stopping and making a slight excavation where they lay their eggs and fulfill their mission. But in the southeastern part of our State the hammocks are scattered throughout the pineland, which is hostile to the snails. However, they obey this call that has been inherited from thousands of generations that have lived under different environment and strike out into the pine woods in search of hammocks. No doubt most of them miss finding a hammock and perish; others find one and create a colony which continues the race in a different locality.

Although there have been several oscillations since the great subsidence of early or middle Pleistocene, yet they have been but slight and in all were never great enough to drown out the snails or high-land vegetation on the greatest elevations or to make dry land of the bays on the southeast coast of our State.

Notwithstanding the fact that all that I have narrated has taken place since early Pleistocene, the briefest bit of geological time, yet I feel sure that long ages were required for the development of lower Florida and to people it with *Liguus*. There was much migration, much hybridizing, the development of new forms, and time was needed for them to adapt themselves to their environment. The whole must have taken many thousands of years.

The death knell of these beautiful snails in Florida has been sounded, and it will be but a few years until all are gone, save it may be in the great Royal palm hammock which is a State reservation. Most of the small hammocks have been destroyed, and in others still standing the snails are fading away before man. In my

bit of forest, into which I have carried many specimens from elsewhere, the birds have attacked them, and now scarcely one remains.

I do not believe that it is possible to make a key that will enable anyone to identify all the material in any considerable collection of Floridian *Liguus*. Without a doubt most of the forms of *fasciatus* and *crenatus* freely hybridize under favorable conditions, with the result that there will be found a certain number of nondescripts that can not be placed anywhere, while some that are of purer strain vary so greatly that it is difficult to classify them. Still I believe that by far the greater part of our material may be referred to some of the names in this descriptive list.

Many of the specimens in our collections have been killed in boiling water, which causes some of the colors of the shell to fade or otherwise change considerably. Under such treatment green is almost certain to become bronzy or dirty grayish. In some cases green lines become abraded even during the life of the animal, or they may change color.

The shells of *solidus* and its varieties are usually decidedly porcellaneous and brilliantly polished, while those of the other two species are less so, but *pseudopictus* is comparatively glassy in some cases but lacking this soft, translucent texture, and on the other hand *eburneus* is occasionally quite porcellaneous.

KEY TO THE FLORIDA LIGUUS

Apex, columellar region or both, pink, purplish, or violet.

Shell decidedly porcellaneous.

Bluish or purplish axial smears present, never reduced to a mere line.

Shell rather thin.

With a double sutural and peripheral row of brown spots—*pictus*.

Without a double sutural and peripheral row of brown spots.

With a brown peripheral and green spiral line or band.

lignumvitae.

Shell solid (green spiral lines absent)———*graphicus*.

Bluish or purplish axial smears absent or if present reduced to a mere line.

Peripheral white zone with a central brown line———*delicatus*.

Peripheral white zone without a central brown line——*simpsoni*.

Shell not porcellaneous.

Shell white, with broad suprapерipheral and basal spiral bands.

Spiral bands yellow or orange———*roseatus*.

Spiral bands not yellow or orange.

Spiral bands chestnut———*castaneozonatus*.

Spiral bands not chestnut.

Spiral bands broken into alternate light and dark axial streaks———*alternatus*.

Shell white, greenish, or smoky white, with few to many green spiral lines which are absent on the periphery———*livingstoni*.

Shell not white.

Shell flesh colored or pinkish.

With a reddish peripheral line and a few brown spots on the upper spire ----- *elegans*.

Without a reddish peripheral line and a few brown spots on the upper spire.

A few dark spiral lines may be present or absent ----- *lineolatus*.

Shell not flesh colored or pinkish.

Shell pale yellow to orange, or orange brown (usually with a few dark spiral lines) ----- *ornatus*.

Shell not pale yellow to orange, or orange brown.

Shell dark, irregularly marked with green.

Dark spiral lines conspicuous on last whorl.

testudineus.

Dark spiral lines not conspicuous but absent or only faintly indicated.

Shell with axial yellowish flames ----- *castaneus*.

Shell without axial yellowish flames.

Shell variegated, brown, smoky yellow, or bluish ----- *versicolor*.

Apex, columellar region, or both not pink, purplish, or violet.

Shell entirely white.

Shell porcellaneous.

Ground color ivory white with or without a dark peripheral line.

crassus.

Ground color not ivory white with or without a dark peripheral line.

Ground color white, cream, or straw colored.

Shell with a broad basal and suprapерipheral pale yellow band.

solidus.

Shell without a broad basal and suprapерipheral pale yellow band.

Shell with two narrow yellow peripheral bands and one at the suture ----- *solidulus*.

Shell not especially porcellaneous.

Shell of pure white, ivory white, or whitish ground color.

Spiral lines greenish or bronzy.

Whorls well rounded.

Whorls slightly shouldered at summit ----- *vacaensis*.

Whorls not slightly shouldered at summit.

Whorls short and subsolid, dull colored (often with a ledge within its aperture) ----- *lossmanicus*.

Whorls not short or dull colored (last whorl often bronzy or greenish) ----- *mosieri*.

Whorls but slightly rounded.

Shell with the columella curved ----- *matecumbiensis*.

Shell with the columella not curved.

Shell solid ----- *capensis*.

Shell not solid.

Shell thin.

Shoulder generally angulated (not small).

septentrionalis.

Shoulder not generally angulated (small).

elliottensis.

- Spiral lines not greenish or bronzy.
 Spiral lines broad, yellow-----cingulatus.
 Spiral lines not yellow.
 Spiral lines reduced to mere indication of dark lines on
 base-----eburneus.
 Shell not of pure white, ivory white, or whitish ground color.
 Ground color yellow to orange or greenish yellow or ashy.
 Double row of brown spots present at the suture---pseudopictus.
 Double row of brown spots not present at the suture----luteus.
 Ground color not yellow to orange or greenish yellow or ashy.
 Ground color dark with yellowish axial markins---marmoratus.

DESCRIPTION OF GENERA AND SPECIES

Genus *LIGUUS* Montfort

All material referred to which was obtained by others or which has been seen in other collections is duly credited: the rest was collected by the author. I have not given synonymy partly because I do not have access to the necessary literature.

Shell imperforate, oblong to ovate-conic, with simple, usually thin, unexpanded lip and obtuse, vertically wrinkled or smooth nepionic whorls which are more or less rounded; columella straight or twisted-truncate at base; color white, yellow, brown, orange, green, or bronzy.

LIGUUS SOLIDUS Say

Plate 1, fig. 1

1825. *Achatina solida* SAY, Journ. Acad. Sci. Philadelphia, vol. 5, p. 122.

Shell thin to solid, generally elongated, usually with rather flattened whorls; color white, cream, or yellow, sometimes variously painted; brilliantly polished and generally having a decidedly porcellanous texture; axial region white, pink, or purplish.

Western part of Cuba; Lower Florida Keys; central islands of the Upper Florida Keys.

The only character by which this species can always be separated from *fasciatus* and *crenatus* is the brilliant porcellanous texture of the shell, and certain specimens of *pseudopictus* are somewhat wanting in this, being almost glassy. Usually the color does not become darker toward the lip, but in a few *solidulus* which I have obtained on Stock Island near Key West it does. And some of these have narrow, spiral, bronzy lines on the last whorl exactly after the manner of certain forms of *crenatus*. Yet I believe that it should stand as a species distinct from *crenatus* and *fasciatus*, as I have no doubt that it represents a different line of development.

LIGUUS SOLIDUS SOLIDUS Say

Plate 1, fig. 7

1825. *Achatina solida* SAY, Journ. Acad. Nat. Sci. Philadelphia, vol. 5, p. 122.

Shell rather solid, usually elongated, very glossy and of a decidedly porcellanous texture; whorls generally somewhat flattened; sutures impressed; color ivory white to straw colored with a broad, faint yellow band above the periphery and a wide, faint yellow basal band; axial region white.

Length 44, diameter 22 mm.; length 49, diameter 24 mm.; length 63, diameter 29 mm.

Key West; Sugarloaf Key; Big Pine Key; No Name Key; Little Pine Key. Probably once an inhabitant of all the drier islands of the lower chain of keys. Some of the specimens received from residents of these islands are not much elongated.

LIGUUS SOLIDUS SOLIDULUS Pilsbry

Plate 1, fig. 2

1912. *Liguus solidus solidulus* PILSBRY, Journ. Acad. Nat. Sci. Philadelphia, p. 463, pl. 37, fig. 2a.

Shell rather thin, slightly to moderately elongated; whorls more rounded than in *solidus*; color pattern generally an ivory white ground with two narrow faint yellow bands at the periphery, one at the suture and one on the base, sometimes with a few dark, spiral lines on the last whorl; whole surface glossy and porcellanous, axial region white.

Length 60, diameter 28 mm.; length 60, diameter 30 mm.

Entire chain of the Lower Florida Keys.

I collected specimens on Stock Island which are more richly colored back of the aperture than on the rest of the shell, and some have from two to eight narrow spiral lines on the last whorl. I have in my collection a set of specimens received from an exchange and labeled "Monroe County, Fla.," one of which has no real distinction of banding but is nearly uniform yellowish on the last whorl, and another has faint, broad, yellow bands that break up into blotches.

LIGUUS SOLIDUS CRASSUS Simpson

Plate 1, fig. 8

1920. *Liguus solidus crassus* SIMPSON, Proc. Biol. Soc. Washington, vol. 33, p. 126.

Shell very solid, of medium size, with somewhat rounded whorls; columella heavy and decidedly truncated; color a uniform ivory

white with sometimes a narrow, bronzy peripheral line; aperture having a strong, white ledge within; axial region white.

Length of type, 43, diameter 27 mm.

Big Pine Key; Ramrod Key, Frazer; Key West, Henderson collection.

In 1885 I found the type at Watson's hammock on Big Pine Key, a very solid shell with the tip slightly truncated. A shell from Key West was given me by the late Mr. John R. Henderson.

LIGUUS SOLIDUS PICTUS Reeve

Plate 1, fig. 3

1842. *Achatina picta* REEVE, Proc. Zool. Soc., London, p. 56; Conch. Syst., vol. 2, p. 178, fig. 10.

Shell thin to subsolid, polished, of medium size, with somewhat rounded whorls; columella straight or slightly twisted and rather thin; surface straw colored or grayish yellow with a pink apex and several vertical or slightly zigzag stripes on the fourth whorl which gradually pass into a double row of squarish brown spots farther down the shell and continue along the suture and periphery of the last whorl to the aperture. These spots may be opposite or alternate or irregularly placed. In addition there are occasional axial bluish smears as in *graphicus*.

Length, 41; diameter, 25 mm.

Big Pine Key; Island of Cuba, probably.

I have said elsewhere that I believe this form to be a native of Cuba and that it has only recently arrived on our shores. I see no difference in shells credited to this island and Big Pine. I have a dead shell that I collected near the present railway station on the latter and a fine specimen received from the late A. G. Wetherby labeled "*Achatina fasciata*, Cuba." In the shells I have seen the columella is white, thin, and straight, but Pilsbry states in the manual (vol. 12, ser. 2, p. 171) that it is more or less, or not, truncated. It is an exceedingly rare form of which I have seen only four specimens, and it is probably extinct in Florida.

LIGUUS SOLIDUS GRAPHICUS Pilsbry

Plate 1, fig. 10

1912. *Liguus solidus graphicus* PILSBRY, Journ. Acad. Nat. Sci. Philadelphia, ser. 2, Vol. 15, p. 463, pl. 37, figs. 1, 1a.

Shell usually large, solid, more or less elongated, having flattened whorls and deep sutures; columella often slightly twisted but scarcely truncated; color, pale yellow with pink or purplish axial

region, the third and fourth whorls painted with longitudinal or slightly zigzag blotches and strigations, and these become darker and more irregular on the next two; there is a rather broad white sutural and peripheral band with a dark central line, and it is usually bordered by a dark broken line on the spire and occasionally on the body whorl. Sometimes there is a broken brown line below the white band on the body whorl. The base may be uniform yellow or flamed with irregular brown blotches, and there are generally one or two bluish axial smears on the body and penultimate whorls.

Length 69, diameter 30 mm.; length 60, diameter 30 mm.

Lower Florida Keys from Little Pine Key west to Boca Chica; West Summerland Keys of the upper chain. Formerly the most abundant of any of the forms on the Lower Keys. I have never found even recognizable fragments of it west of Boca Chica Key, but it may have formerly extended to Key West. I recently received a very well-preserved specimen which had been inhabited by a land crab from Mr. Cleveland Wells of Big Pine, who collected it on the West Summerland Keys, near the lower end of the upper chain, and I found fragments of the same on one of these islets in the thick, tropical scrub. It may have reached these islets by drifting from Big Pine Key, which is only a short distance away. Its shell is one of the most magnificent of all the land snails, being large, solid, and richly porcellaneous, highly polished and finely painted.

LIGUUS SOLIDUS LIGNUMVITAE Pilsbry

Plate 1, fig. 11

1912. *Liguus fasciatus lignumvitae* PILSBRY, Journ. Acad. Nat. Sci. Philadelphia, ser. 2, vol. 15, p. 461, pl. 37, figs. 4 a-d.

Shell large, somewhat elongated, thin but strong, with slightly rounded whorls; axial region pink or purplish; general color pale or greenish yellow, sometimes almost white, often becoming ashy on the spire, the second to fourth whorls having light-brown straight or wavy axial stripes, and these become broader and purplish farther down the spire; in addition there are few to numerous bluish smears and blotches on the last one or two whorls; beginning at about the fourth whorl and extending to the aperture there is often a single or double row of dark dots at the suture, and there is a whitish peripheral band with a reddish line in its center. Besides these there are generally a few to several green spiral lines or bands on the lower half of the last whorl.

Length 65, diameter 30 mm.; length 50, diameter 29 mm.

Lignumvitae Key, mostly on the south part; Lower Matecumbe Key; abundant on both islands and less elongated on the latter.

Certain specimens from the former locality are quite solid and lack spiral green lines, approaching so closely to *graphicus* that it is difficult to separate them.

LIGUUS SOLIDUS DELICATUS Simpson

Plate 1, fig. 4

1920. *Liguus solidus delicatus* SIMPSON, Proc. Biol. Soc. Washington, vol. 33, p. 133.

Shell usually rather thin and elongated, with somewhat flattened whorls, straw colored to buff, sometimes having an occasional narrow bluish axial smear or dark rest line; second to fourth whorls usually with faint, longitudinal, brownish lines; there is a single, narrow spiral dark line above the sutures and on the periphery, sometimes very faintly white bordered. Axial region straw colored or purplish. Rarely there are a few traces of spiral green lines on the base of the shell.

Length 65, diameter 28 mm.; length 55, diameter 25 mm.

Lower Matecumbe Key; west end of Upper Matecumbe Key; Indian Key (Wurdeman). I have several hundred specimens from Lignumvitae Key, but none that I can refer with certainty to this form. Rarely a specimen shows a few faint dots at the suture. Usually distinct from the other forms, but an occasional intermediate occurs.

LIGUUS SOLIDUS SIMPSONI Pilsbry

Plate 1, fig. 5

1920. *Liguus solidus lineatus* SIMPSON, Proc. Biol. Soc. Washington, vol. 33, p. 121.

Shell large, usually elongated, thin but strong, with a pinkish axial region; pale greenish straw color, entirely lacking bluish smears or other variegation and without a dark peripheral band, usually with a few green spiral lines or bands on the base.

Length 60, diameter 28 mm.; length 50, diameter 26 mm.

Lignumvitae and Lower Matecumbe Keys. One shell received from Dr. H. A. Pilsbry labeled "Grassy Key." I first bestowed the name *lineatus* on this form, but Doctor Pilsbry called my attention to the fact that it had been used for a *Liguus* by Valencennes and suggested the name *simpsoni* for it. It has been very abundant on Lignumvitae Key, where it is found mostly on the northern part of the island. Certain shells of this form superficially rather closely resemble some of the specimens of *subcrenatus* but may always be distinguished on account of having a rosy apex, while that of the latter is milky white.

LIGUUS SOLIDUS PSEUDOPICTUS Simpson

Plate 1, fig. 9

1920. *Liguus solidus pseudopictus* SIMPSON, Proc. Biol. Soc. Washington, vol. 33, p. 122.

Shell large, somewhat elongated, thin, with the axial region *white*, with slightly rounded whorls and well-impressed sutures, grayish white to greenish yellow, sometimes cream colored and having occasional bluish axial smears, the third, fourth, and sometimes the fifth and sixth whorls often having zigzag brownish lines and blotches; last whorl sometimes greenish-yellow with green, spiral lines; there is a double row of sutural squarish brown spots from columella thin and straight; texture glassy to porcellanous. There is a form with broad, brown zigzag strigations on the fourth, fifth, and sixth whorls.

Length of type 50, diameter 36 mm.; length of a large specimen 64, diameter 32 mm.

Lower Matecumbe Key near the middle of the island.

Undoubtedly derived from the form *lignumvitae* and analogous to *pictus* from which it differs in its much larger size, its thinness of shell, duller color, and white axial region. Occasional intermediates connecting it with *lignumvitae* are found. The young shells have a smoky peripheral band such as is seen in *pictus*. Some of the shells are porcellanous but the majority are but slightly so and a few have green spiral lines on the base. A form has broad, brown, zigzag stripes.

LIGUUS FASCIATUS Müller

1744. *Liguus fasciatus* MÜLLER, Verm. Terr. et Fluv., vol. 2, p. 145. 1774.

Shell imperforate, oblong-conic, smooth, usually glossy and highly painted, the colors being white, yellow, brown, green, orange, and even scarlet; whorls rounded; axial region always wholly or in part pink or purplish; columella thin and straight to thick and twisted or truncate.

Entire island of Cuba; Cozumel Island; lower Florida along the coast at Marco on the west to Fort Lauderdale on the east; Upper Florida Keys.

In a majority of the Floridian subspecies some of the earlier whorls show brownish regular or zigzag lines or even blotches, such markings being present in *castaneus*, *testudineus*, *versicolor*, *castaneo-zonatus*, *alternatus*, *miamiensis*, *elegans*, and occasionally in *livingstoni*; but they appear to have faded out in *roseatus*, *lineolatus*, and *ornatus*. Without a doubt this color pattern which we see strongly developed in Cuban shells of this species was one of the earlier char-

acters of *fasciatus* and in fact of the genus. It has become obliterated in all the forms of *crenatus* save *marmoratus*, in *ornatus*, in typical *solidus*, *solidulus*, *crassus*, *simpsoni*, and nearly so in *delicatus*.

The axial region in forms of *fasciatus* may be pink or purplish at the tip of the spire and white at the base or the opposite, but there is always more or less color to it, while that of *crenatus* in all its forms is pure white. This may seem like a trivial character on which to found a species, but it is the only constant one, and with Pilsbry I believe it is one of long standing, the color having faded from the forms with white axis a long time ago.

LIGUUS FASCIATUS CASTANEOZONATUS Pilsbry

Plate 1, fig. 12

1912. *Liguus fasciatus castaneozonatus* PILSBRY, Journ. Acad. Nat. Sci. Philadelphia, ser. 2, vol. 15, p. 460, pl. 39, figs. 23, 23 a.

Shell rather solid, with moderately rounded whorls; axial region pink to deep purple; surface with a white ground; third whorl with faint, irregular axial or zigzag brown striations or blotches which become darker and closer until at about the fifth or sixth whorl they form a broad, more or less solid chestnut or black spiral band. There is a similar basal band and usually a narrow reddish brown peripheral line and all three extend to the aperture.

Length 43, diameter 24 mm.; length of a large shell from Key Largo 60, diameter 30 mm.

Key Vaca group; Upper Matecumbe Key northeast along the chain to Elliotts Key and on several of the small adjacent islands; Middle and East Cape Sable; Chokoloskee; the south shore of the mainland as far east as Madeira Bay; the rocky ridge of the lower east coast from Miami southwest to Long Pine Key in the Everglades; Pinecrest.

A striking and beautiful *Liguus* which is very abundant and widely distributed, occupying nearly all the region in Florida inhabited by the species to which it belongs. It is apparently wanting from Miami northward; on the west coast above Chokoloskee and on a few of the middle keys of the upper chain. At Miami it may hybridize with other forms. A *Liguus* occurs in Cuba of which I have a specimen from Salto Manantiales which is extremely close to this, and I have shells from Andros de Cisneros labeled "Isla de Cuba" very near our subspecies. It is quite possible that *castaneozonatus* or its prototype may have sprung from *blaineanus*, a Cuban form now confined within narrow limits. In some Floridian shells the dark band is more or less broken up, while in others it is nearly continuous.

LIGUUS FASCIATUS ALTERNATUS Simpson

Plate 2, fig. 1

1920. *Liguus fasciatus alternatus* SIMPSON, Proc. Biol. Soc. Washington, vol. 33, p. 123.

Shell medium sized, rather solid, with bright pink axial region; color white with a broad, spiral, supraperipheral band consisting of alternating light and dark axial chestnut lines and bars; there is sometimes a faint, narrow peripheral reddish line and there is a broad band at the base similar to the wide one above; columella straight or very slightly twisted.

Length of type 45; diameter 24 mm.

Timb's hammock; Black Creek, Paradise Key, all in Lower Dade County, Fla.

This form, which is probably a sport from *castaneozonatus* seems to be confined to a few localities in the south end of the mainland of the State. Certain shells have the broad bands replaced in places by white or yellowish.

LIGUUS FASCIATUS ROSEATUS Pilsbry

Plate 2, fig. 7

1912. *Liguus fasciatus roseatus* PILSBRY, Journ. Acad. Nat. Sci. Philadelphia, ser. 2, vol. 15, p. 448, pl. 38, figs. 11, 11a, 11b, 13, 15, 19, 19a.

Shell subsolid to solid, with somewhat rounded whorls; axial region pink to purplish; surface white, with a broad supraperipheral band of yellow, brownish yellow, or orange; rarely this band is overlaid with a few green spiral lines; there is a similar basal band and occasionally a faint narrow reddish peripheral line; parietal wall pink or tinted purplish, darker colored along its outer edge, sometimes having deep pink streaks; columella twisted and subtruncate in heavy shells, thinner and straight in less solid ones.

Length 45, diameter 25 mm.; length 40, diameter 21 mm.

Entire area occupied by *Liguus* in Florida except the extreme northeast portion, the Lower Keys, and the central part of the Upper Keys. One specimen from Pinecrest.

This is the most widely distributed form of *Liguus* in Florida, and it is not exceedingly variable. Some of the shells are very beautiful, the darker bands being a brilliant orange. Rarely a few dark spiral lines on the last whorl.

LIGUUS FASCIATUS LINEOLATUS Simpson

Plate 2, fig. 8

1920. *Liguus fasciatus lineolatus* SIMPSON, Proc. Biol. Soc. Washington, vol. 33, p. 125.

Shell subsolid to solid, with somewhat rounded whorls; axial area pink or purplish red; surface whitish, flesh colored, or yellowish,

with or without a buff, greenish, or reddish spiral peripheral line; there are often one or more faint bronzy spiral lines on the base. Rarely there are one or more spiral lines on the upper part of the last whorl; columella usually twisted, almost truncate in heavy shells.

Length 63, diameter 32 mm.; length 53, diameter 27 mm.; length 37, diameter 20 mm.

Vaca group of the Upper Keys; all the Upper Keys from Upper Matecumbe to and including Elliotts Key; mainland from Marco south to Cape Sable; south shore of the mainland.

A widely distributed and variable form. Shells from the upper end of Largo and the small keys near it are often small, solid, and have more or less flattened whorls, while in others on these same islands they are large and somewhat rounded. This latter form occupies Pumpkin Key exclusively, although *roseatus* is found on Key Largo that is separated from it by only a narrow and very shallow strait. Pilsbry includes it with his *roseatus*, but it seems to me to be perfectly distinct and the two have a somewhat different distribution. Its spiral lines may occur on the periphery while those of *livingstoni* do not.

LIGUUS FASCIATUS ELEGANS Simpson

Plate 2, fig. 2

1920. *Liguus fasciatus elegans* SIMPSON, Proc. Biol. Soc. Washington, vol. 33, p. 124.

Shell generally small to medium size, solid, conical, with moderately rounded whorls, the second to the fifth being marked with irregular brown axial stripes and blotches; axial region a rich pink, with two or more deeper colored lines on the columellar area; general surface flesh colored; there is a reddish spiral line around the periphery and at the suture and sometimes one or more greenish ones on the last whorl; columella twisted or truncated.

Length of type 40, diameter 22 mm.; length of a large shell 58, diameter 30 mm.

A small key east of Whitewater Bay, where this and *roseatus* were the only form of *Liguus*; small hammock on Long Pine Key, one very large specimen; Paradise Key; Costello's hammock; Miami; Arch Creek; Pinecrest.

This form may be distinguished from *lineolatus* by the strigations and blotches on the earlier whorls and it inhabits an entirely different area from that subspecies, being strictly confined to the rocky ridge of the lower mainland and the Pinecrest region. I collected *Liguus* in the vicinity of Cabanas, Cuba, that very closely resemble this.

LIGUUS FASCIATUS LIVINGSTONI Simpson

Plate 2, figs. 3 and 9

1920. *Liguus fasciatus livingstoni* SIMPSON, Proc. Biol. Soc. Washington, vol. 33, p. 124.

Shell variable in size, solid, with rounded whorls; axial region purplish pink to deep purple, the parietal wall often showing deeper-colored streaks; surface white, usually smoky, greenish or pale yellowish green on the last whorl, with from a few to several spiral green lines on the last two whorls but wanting such markings at the periphery; columella straight or twisted.

Length of type 42, diameter 24 mm.; length of large shell 58, diameter 27 mm.

Fort Lauderdale (Squires), south along the rocky ridge to Long Pine Key in the Everglades, rare at the lower end of its area. I have a shell of *fasciatus* from Luis Lazo in Western Cuba 56 mm. in length that is very close to others that I got on cypress trees at the head of the Miami River, Fla. It agrees in size, color, markings, and weight to the last detail. The species *livingstoni* differs from *lineolatus* in having colder colors, in usually becoming darker toward the aperture and the more numerous green spiral lines which are absent on the periphery, also in lacking a reddish peripheral line; besides it has a different distribution. Recently a specimen of this has been found at Fort Lauderdale by Carl Squires.

LIGUUS FASCIATUS MIAMIENSIS Simpson

Plate 2, fig. 4

1920. *Liguus fasciatus miamiensis* SIMPSON, Proc. Biol. Soc. Washington, vol. 33, p. 124.

Shell usually small to medium size, subsolid, with rounded whorls; axial region light to deep purple; body of the shell whitish, the fourth, fifth, and sometimes the sixth whorls having a wide, median band consisting of irregular brown blotches often on a yellowish ground, and this usually ends abruptly on the last whorl. The latter part of the last whorl ordinarily has a number of narrow, spiral green lines which extend to the aperture.

Length 46, diameter 23 mm.; length 38, diameter 38 mm.

Ojus south and west along the rocky ridge to Paradise Key.

Doubtless a hybrid with some of the characters of *castaneozonatus*. I have a shell from Nuevitas, Cuba, which though larger and more elongated has the same general markings as this form. Some specimens of *miamiensis* have a reddish peripheral line, while others scarcely show a trace of it. It is quite likely that the ancestors of this form drifted from Cuba and became established in the great Miami hammock.

LIGUUS FASCIATUS ORNATUS Simpson

Plate 2, fig. 10

1920. *Liguus fasciatus ornatus* SIMPSON, Proc. Biol. Soc. Washington, vol. 33, p. 124.

Shell subsolid, small to medium size, rather inflated; axial region pink or purplish; surface yellowish, always becoming darker toward the aperture, where it may be deep yellow, orange, pale yellowish brown, or even scarlet; there is sometimes a faint lighter-colored peripheral band and generally a few green or bronze spiral lines on the last two whorls; columella straight or twisted.

Length of type 46, diameter 26 mm.

Long Pine Key and hammocks along the rocky ridge to the Miami River. One specimen at Ojus.

It differs from *roseatus* in having no distinct suprapерipheral band, the entire shell being yellowish or brownish, and in always being darker on the last whorl and base. Occasionally the columella is nearly white, but the apex is colored. There are intermediates between it and *roseatus*, and it may be a sport from or hybrid of that form. Some shells flush into scarlet at the aperture.

LIGUUS FASCIATUS VERSICOLOR Simpson

Plate 2, figs. 5 and 11

1920. *Liguus fasciatus versicolor* SIMPSON, Proc. Biol. Soc. Washington, vol. 33, p. 125.

Shell small to medium sized, solid, brilliantly polished, with somewhat rounded whorls; axial region pink or purplish at the tip but usually only slightly colored at the columellar area. The ground color may be greenish to brownish with narrow zigzag axial yellow stripes and blotches, or it may vary to yellowish, in which case the stripes and blotches are wanting, and it may have a double row of irregular brown spots at the suture and on the periphery. There is a smoky band with a lighter center at the periphery, and it may be considerably broken up or almost entire. In some shells the general tint is bluish or bluish black.

Length of type 38, diameter 22 mm.; length 40, diameter 24 mm.

Long Pine Key in the lower Everglades. This island is 8 miles long and 4 wide; it is covered with a forest of Carribean pine and has fine hammocks scattered over it. It is in one large hammock on this key that this form has its metropolis and is rarely found elsewhere on the island. There is an abundance of material that completely connects the extremes of color in this exceedingly variable form. Very rarely there are a few faint spiral dark lines on the base of the shell. This is a wonderfully beautiful *Liguus*, the most

variable of any subspecies I know. So far as I am aware, it is confined to this large key.

LIGUUS FASCIATUS CASTANEUS Simpson

Plate 2, figs. 6 and 12

1920. *Liguus fasciatus castaneus* SIMPSON, Proc. Biol. Soc. Washington, vol. 33, p. 126.

Shell moderately solid, rather large; apex whitish to deep pink; columella purplish white to dark purple; surface chestnut to almost black, the upper part and sometimes all of the shell marked with pale to deep yellow, irregular axial stripes which are often zigzagged; there is a broad, sometimes double smoky peripheral band with a lighter one between, and these may be almost obliterated in very dark shells; columella slightly twisted.

Length 52, diameter 28 mm.

Miami to Long Pine Key.

Typically this form is darker than *testudineus*, its near ally; it lacks the dark spiral lines of the latter and has a more distinctly defined color pattern, but there are occasional intermediates. Shells from Cox's hammock and Paradise Key are nearly black.

LIGUUS FASCIATUS TESTUDINEUS Pilsbry

Plate 3, fig. 1

1913. *Liguus fasciatus testudineus* PILSBRY, Journ. Acad. Nat. Sci. Philadelphia, ser. 2, vol. 15, p. 457, pl. 39, figs. 20 a to 20 f.

Shell subsolid, with rather rounded whorls; axial region generally pale pinkish to purplish, the columellar area sometimes almost white; color varying from yellowish to brown; in the darker shells there is a pattern of irregular, light, wavy blotches and strigations; in the lighter-colored specimens there may be only a double series of indistinct spots at the suture; certain examples have bluish clouds on the spire; there is usually a double smoky or dark chestnut band at the periphery, with a lighter one between, and there are dark spiral lines on the last two whorls. Columella generally thin, sometimes twisted.

Length 45, diameter 23 mm.; length 43, diameter 25 mm.

Miami hammocks.

A beautiful, often glossy and very variable form which seems to be confined to the great Miami hammock. It differs from *castaneus* in being lighter colored, in its occasionally clouded surface, and in having dark spiral lines. Certain specimens closely approach some of the lighter forms of *versicolor*, but the former have the spiral lines which are lacking in the latter, though there are some intermediates. There are hybrids which have numerous spiral, green lines on the last whorl.

LIGUUS CRENATUS Swainson

1821. *Achatina crenata* SWAINSON, Zool. Ill., vol. 1, pl. 58.

Shell medium sized to large, thin to solid, usually not porcellanous, with more or less rounded whorls, typically white with spiral green lines which become slightly impressed near the aperture and end in small crenations on the thin edge of the outer lip; entire axial region always white.

Whole island of Cuba; coast of Florida from Fort Lauderdale around to Lossmans River on the west; Upper Florida Keys.

This species received the name *crenatus* because of the slight crenations at the edge of the shell where the green spiral lines end. But only the forms having these lines show crenations; and, as a matter of fact, many specimens of *fasciatus* that have similar lines show slight teeth. Usually lacking dark spiral lines at the periphery. It freely hybridizes with *fasciatus*, a fact which is proven by *Liguus* of the two types hatching from a single set of eggs here in Florida, and without doubt the same thing is true in Cuba. I have no evidence that *fasciatus* or *crenatus* hybridize with *solidus* within our borders, although on Lower Matecumbe Key *subcrenatus* is found in the same hammocks as forms of *solidus*, and on Upper Matecumbe one form of *solidus*, *delicatus*, and *matecumbiensis*, *luteus*, and *castaneozonatus* have been found and there is not the slightest intergradation. But I am inclined to believe that *solidus* and *fasciatus* hybridize in Cuba. The completely white axial region is the best distinguishing character of this species.

LIGUUS CRENATUS MARMORATUS Pilsbry

Plate 3, figs. 2, 3, 7, and 8

1912. *Liguus fasciatus marmoratus* PILSBRY, Journ. Acad. Nat. Sci. Philadelphia, ser. 2, vol. 15, p. 455, pl. 37, figs. 9, 9a, 9d, 10.

Shell generally elongated, thin to solid, with only moderately rounded whorls, of which the first three and the entire axial region are white; on the next whorl there are irregular alternate white and brownish axial stripes, below which the ground color becomes chestnut to almost black, and it is marked with axial yellow or whitish stripes or flask-shaped blotches; there is a light band at the suture and on the periphery, and at the latter place it is usually bordered by two dark ones; last whorl generally showing dark spiral lines; aperture white within; columella thin and straight to heavy and truncate.

Length 65, diameter 28 mm.; length 43, diameter 22 mm.

Key Vaca and doubtless other islands of the Vaca group; Long Island of the Upper Keys, Key Largo; Porgy Key, doubtful; Cape

Sable; Chokoloskee; Long Pine Key; Cox's hammock; Snapper Creek; Costello's hammock; Miami hammock; Pinecrest, south-central Everglades, not typical.

A striking and very variable form, probably a hybrid, which commonly bears the name of the "black snail"; and, considering its rarity, it has a wide distribution. Rarely a shell shows bluish or greenish cloudings like *versicolor*, and one specimen from Key Vaca is marked very much like the lighter-colored forms of that subspecies. In one shell from the Miami hammock and another from Snapper Creek the axial whitish strigations continue to the base, and there is a dark peripheral band without a light center. One shell from Vaca is very thin and inflated and bears some resemblance to *Oxystyla resus*. Without a doubt this form has been an inhabitant of the Chokoloskee region. A Mr. House, who resided there, took me in his boat to a place where there was formerly a fine hammock where he said he found the black snail, but it had been cut down and made into a field. We found dead shells there which still showed that they were *marmoratus*. It is a nondescript and combines characters of *fasciatus* and *crenatus*.

I have no doubt but that this or an analogous form inhabits or has recently inhabited some part of Cuba, although, so far as I know, nothing like it has been found, and that it has migrated and become established on Key Vaca, from which it spread along the Upper Keys and crossed to the mainland on the old land bridge. It reached Chokoloskee on the southwest coast and has probably been swept across to the rocky ridge during time of a tidal wave. On this ridge it has again hybridized, this time with forms of *fasciatus*, and has produced *versicolor* on Long Pine Key; *castaneus*, which has spread up to the Miami hammock; and at the latter place it has developed into *testudineus*. Throughout this ridge occasional shells are found which have the entire axial region pure white, and these I refer to *marmoratus*.

LIGUUS CRENATUS VACAENSIS Simpson

Plate 4, fig. 10

1920. *Liguus crenatus vacuensis* SIMPSON, Proc. Biol. Soc. Washington, vol. 33, p. 122.

Shell usually large, with convex spire, subsolid to solid, with deep sutures and the last and penultimate whorls slightly flattened, white or shaded greenish with sometimes a few spiral green or bronzy lines on the body or base; texture somewhat porcellanous; columella heavy and twisted or truncated.

Length of type 54, diameter 27 mm.; length of large shell 64, diameter 33 mm.

Vaca Keys; Long Island; Key Largo; Angelfish Key; Sands Key; Northwest and Middle Cape Sable (?) near Flamingo (?).

A fine, usually solid, somewhat porcellanous form which generally has the last whorls slightly flattened in the middle but well shouldered. It constantly differs from *capensis* in being less elongated and having a convex spire. I am not quite certain about the mainland specimens.

LIGUUS CRENATUS CAPENSIS Simpson

Plate 3, fig. 9

1920. *Liguus crenatus capensis* SIMPSON, Proc. Biol. Soc. Washington, vol. 33, p. 122.

Shell large, solid, much elongated, with straight sides and somewhat chalky texture; whorls slopingly flattened; sutures not very deep; surface white or slightly greenish tinted on the last whorl, with a few to several spiral lines on the last or last two whorls, those above the periphery green and the basal ones ashy brown; aperture small, rather short, the outer lip not greatly oblique; columella generally thin and straight or only slightly twisted.

Length of type 58, diameter 27 mm.; length 60, diameter 26 mm.

Northwest, Middle, and East Cape Sable; hammock near Flamingo; near Cuthbert Lake 20 miles east of Northwest Cape Sable (Livingston).

More elongated than any other Florida *Liguus*, with very straight sides and ashy brown basal lines. A specimen found on Northwest Cape Sable in 1885 had a broad, brilliant green belt above the periphery, but it fell into the grass and was lost. The green lines are often worn away on living shells.

LIGUUS CRENATUS MATECUMBENSIS Pilsbry

Plate 3, fig. 4

1912. *Liguus crenatus matecumbensis* PILSBRY, Journ. Acad. Nat. Sci. Philadelphia, ser. 2, vol. 15, p. 446, pl. 37, figs. 5, 5a.

Shell medium to large, rather thin to subsolid, varying from somewhat slender to inflated, with but slightly rounded whorls and a faint angulation just below the periphery, creamy white to pale greenish yellow with a few spiral green or bronzy lines on the last whorl or two, spire rounded; aperture large, rather long; outer lip oblique; columellar area creamy to yellowish; there is sometimes a golden flush on the parietal wall; columella thin and incurved.

Length 55, diameter 29 mm.

Length of a slender shell 50, diameter 23 mm.

Upper Matecumbe Key; Middle and East Cape Sable; Flamingo and hammocks in the vicinity; east to Madeira Bay. Very abundant on the mainland.

This differs from other forms of *crenatus* in the large aperture, the incurved columella, and the more oblique outer lip. In most shells the colored lines become abraded during life and sometimes change from green to bronze. In some shells the yellow columellar flush is present; in others it is wanting.

LIGUUS CRENATUS SUBCRENATUS Pilsbry

Plate 3, fig. 10

1912. *Liguus crenatus subcrenatus* PILSBRY, Journ. Acad. Nat. Sci. Philadelphia, ser. 2, vol. 15, p. 445, pl. 37, figs. 7, 7a.

Shell large, rather elongated, thin but strong, with but slightly rounded whorls; surface glassy white except the apical region which is dull or milky white; last whorl having a few spiral green lines which are mostly on the base; columella thin and straight.

Length 60, diameter 28 mm.; length 70, diameter 32 mm.

Grassy, Lower Matecumbe, and Windleys Keys; Long Island; Key Largo.

A thinner shell than *vacaensis*, and it has less convex sides; it is more glassy, being almost as much so as *septentrionalis*. Sometimes the later whorls are slightly tinted with green. The shell whose dimensions are last given and which I collected on Windleys Key is the largest *Liguus* I have seen from Florida. Apparently about a quarter of an inch of its apex has been broken off and sealed up, and if it were perfect it would probably measure 77 mm. It very likely had nine whorls, though most shells of this form have but eight. I collected *Liguus* at Cape San Antonio, Cuba, which were quite similar to this subspecies.

LIGUUS CRENATUS ELLIOTTENSIS Pilsbry

Plate 3, fig. 11

1912. *Liguus crenatus elliotensis* PILSBRY, Journ. Acad. Nat. Sci. Philadelphia, ser. 2, vol. 15, p. 447, pl. 37, figs. 3, 3a, 3b.

Shell small to medium sized, somewhat inflated, thin and usually fragile, with six to six and a half whorls which are generally but slightly rounded, lusterless white, sometimes having transparent gray streaks, and occasionally dark spiral lines on the lower half of the last whorl; columella thin and straight or but slightly twisted.

Length 37, diameter 20 mm.; length of a large dead shell from Old Rhodes Key 44, diameter 25 mm.

Elliotts Key; Old Rhodes Key; Scott's place on Key Largo (National Museum collection).

A small form with rather negative characters, being thin and simply colored. I found a number of dead specimens on Old Rhodes

Key, some of them being considerably larger than those from Elliotts Key. Pilsbry, who has seen numerous perfect shells, says that there is a faint yellow sutural line and usually some yellowish olive green, chiefly basal lines.

LIGUUS CRENATUS LUTEUS Simpson

Plate 3, fig. 12

1920. *Liguus crenatus luteus* SIMPSON, Proc. Biol. Soc. Washington, vol. 33, p. 123.

Shell varying from small to large and from thin to solid; axial region white, with the columella generally twisted or subtruncate; whorls somewhat rounded, with the sutures well impressed; color varying from straw or pale yellow to deep yellow or orange, lighter to white on the earlier whorls, sometimes having from one to several narrow dark or green spiral lines on the last whorl at or above the periphery and fainter lines on the base.

Length of type 63, diameter 18 mm.; length 38, diameter 18 mm.

Vaca group of the Upper Keys; east end of Upper Matecumbe, one specimen; Kep Largo (C. E. Saxton), a fine young specimen; rocky ridge on the south and southeast mainland from Long Pine Key east and north to Dania; Pinecrest, very brilliant.

In most shells there is a sort of ledge inside at the aperture composed of the dull white matter of the interior, and the outer lip is thin and darker colored. Some of the specimens from Key Vaca have the last whorl brilliantly tinted with orange, and I have shells collected back of Larkins and about Dania, the latter locality being near the northern limit of *Liguus* on the east coast, which are very close to the Vaca material. It is an abundant form, and as I have remarked, it is the first to inhabit the incipient hammocks of the great rocky ridge. In some of the larger hammocks it is the only occupant.

LIGUUS CRENATUS CINGULATUS Simpson

Plate 3, fig. 6

1920. *Liguus crenatus cingulatus* SIMPSON, Proc. Biol. Soc. Washington, vol. 33, p. 123.

Shell medium to large sized, thin to subsolid, somewhat shining; whorls varying from flattened to somewhat rounded, pure white, with a broad, pale yellow spiral band above the periphery and another below it; columella twisted.

Length of type 33, diameter 20 mm.

Long Island of the Upper Keys; Key Largo; Middle Cape Sable; East Cape Sable; Flamingo; Long Pine Key (?); Timb's hammock; Lysiloma hammock, both in Lower Dade County; Miami; Lemon City.

Although this form is widely distributed it seems to be rather rare. Externally it is colored much like certain specimens of *Liguus fasciatus roseatus*, but the axial region is pure white throughout. The yellow is paler than it is in that form.

LIGUUS CRENATUS EBURNEUS Simpson

Plate 4, fig. 1

1920. *Liguus crenatus eburneus* SIMPSON, Proc. Biol. Soc. Washington, vol. 33, p. 122.

Shell rather solid, usually of a somewhat porcellanous texture, obese to rather elongated, with rounded whorls, pure or ivory white throughout or rarely having traces of spiral bronzy lines on the base or at the aperture; columella twisted.

Length of type 52, diameter 26 mm.

Timb's hammock, type locality; hammocks along the rocky mainland ridge from Long Pine Key to Lemon City and opposite it on the peninsula; Pinechest, not typical. Has a somewhat porcellanous texture and usually is without traces of spiral lines.

LIGUUS CRENATUS MOSIERI Simpson

Plate 4, fig. 2

1920. *Liguus crenatus mosieri* SIMPSON, Proc. Biol. Soc. Washington, vol. 33, p. 123.

Shell variable in size, subsolid, somewhat polished; whorls moderately to well rounded, the earlier ones white or whitish, the last ones darker, often smoky tinted or dirty greenish and having from two to several green or bronzy spiral lines which are wanting at the periphery; columella straight or slightly twisted.

Length of type 45, diameter 24 mm.; length of a large shell from Miami 50, diameter 27 mm.

Hammocks from Arch Creek southward and westward along the great rocky mainland ridge to Long Pine Key, being most abundant at Miami, the type locality.

This subspecies is nearer the typical Cuban *crenatus* than anything we have, but it averages much smaller than that. However, I have seen shells from Cape San Antonia and other localities in that island that are no larger than the ordinary *mosieri*.

LIGUUS CRENATUS SEPTENTRIONALIS, Pilsbry

Plate 4, fig. 3

1912. *Liguus crenatus septentrionalis* PILSBRY, Journ. Acad. Nat. Sci. Philadelphia, ser. 2 vol. 15, p 447, pl. 37, figs. 6, 6a.

Shell thin but strong, inflated, with but slightly rounded whorls, the last usually subangulate at the periphery, with glassy surface,

pure white or slightly greenish, with from one to seven spiral narrow green or bronzy lines on the last whorl that may extend to the penultimate one; aperture large; outer lip thin; columella straight.

Length 48, diameter 27 mm.; length 42, diameter 23 mm.

Great hammock near Fort Lauderdale; hammocks along the outer shore opposite the town and to the northeastward; south side of New River near its mouth; hammock about a mile south of Fort Lauderdale; hammock north of Arch Creek, where both typical specimens and those hybridized with *fasciatus* were found. A form nearly typical was taken just south of Little River stream.

A well-characterized subspecies, being thin, short, and inflated, highly polished and glassy, usually with a decided peripheral angulation. Sometimes the spiral lines are brilliant green, or they may be bronzy; they are rarely wholly wanting. It has been found in the shore hammock more than 2 miles north of Fort Lauderdale, and this is the most northern authentic locality for *Liguus* in the State of Florida; I have a specimen of *Liguus* from the village of Jamaica, Cuba, which is very close to *septentrionalis*, the only difference being that the Cuban shell is a little more solid and has a slight ledge within the aperture.

LIGUUS CRENATUS LOSSMANICUS Pilsbry

Plate 4, figs. 4 and 9

1912. *Liguus crenatus lossmanicus* PILSBRY, Journ. Acad. Nat. Sci. Philadelphia, ser. 2, vol. 15, p. 448, pl. 37, figs. 8 a, b.

Shell usually small to medium size, inflated, and having decidedly rounded whorls, subsolid to solid; axial region pure white, the columella ordinarily strongly twisted and truncate; there is in the more solid shells a decided ledge or shoulder just inside the aperture; color white, greenish, or yellowish white, usually dull; often there are a few green or bronzy spiral lines and sometimes a dull, broad, yellowish band above and below the periphery.

Length of a shell from the type lot 40, diameter 23 mm.; length of a large shell from Middle Cape Sable 55, diameter 30 mm.

Lossmans Key on the southwest coast to Middle Cape Sable; Rodgers River; John Douthett's place near Flamingo.

A peculiar form and somewhat variable for one having such a limited distribution. Most of the shells are short, solid, with rounded whorls; but others which I refer to this are somewhat lighter in build, are more lengthened, and have less decidedly rounded whorls, and these usually do not show the strong inside ledge. But the two seem to intergrade. Dr. Edward Mercer and I found an extensive colony in an isolated hammock at Middle Cape Sable where some specimens were quite large and had the last whorl flattened